भारतीय मानक
Indian Standard

IS 15477 : 2019

सिरेमिक, पच्चीकारी और पत्थर की टाइलों में प्रयुक्त आसंजक — विशिष्टि

(पहला पुनरीक्षण)

Adhesives for Use with Ceramic, Mosaic and Stone Tiles — Specification

(First Revision)

ICS 83.180; 91.100.25

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Flooring, Wall Finishing and Roofing Sectional Committee, CED 05

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Flooring, Wall Finishing and Roofing Sectional Committee had been approved by the Civil Engineering Division Council.

This standard was first published in 2004. This revision incorporates the experience gained with the use of this standard and brings it in line with the latest developments in this field. The following are the significant modifications incorporated in this revision:

a) Title of the standard has been modified to 'Adhesives for use with ceramic, mosaic and stone tiles — Specification' from 'Adhesives for use with ceramic tiles and mosaics — Specification'.
b) Adhesives have been classified into five types namely, Type 1, Type 2, Type 3, Type 4 and Type 5.
c) Measurement of adhesion strengths have been modified to load per unit area.
d) Measurement of adhesion strengths are now to be done using UTM.
e) Requirements such as slip and deformation of adhesives have been added.
f) Requirements such as rheology and storage stability have been done away with.

This standard also specifies the procedure for the tests to evaluate the properties of different types of tile adhesives suitable for fixing tiles of different porosity on various substrates.

The suitability of a tile adhesive largely depends on the following factors of tiles to be fixed: (a) The porosity/density; (b) Size of tile; (c) The nature, surface and location of the substrate; and (d) The area of application, interior or exterior submerged conditions or wet areas.

As the tiles installed should establish 100 percent contact with the substrate. However, the following minimum contact requirements should be used for designing the adhesive: (a) 95 percent contact area for high demanding conditions; (b) 85 percent minimum contact area for normal conditions; and (c) In case of using spot bonding technique or blob technique for fixing of tiles for decorative purposes or internal use, where it is sufficient to have 50 percent contact area, the shear bond strength of the proposed adhesive should be at least 10 MPa.

While formulating this standard, considerable assistance has been derived from the following ISO standards:

ISO 13007-1 : 2014	Ceramic tiles — Grouts and adhesives — Part 1 : Terms, definitions and specifications for adhesives
ISO 13007-2 : 2013	Ceramic tiles — Grouts and adhesives — Part 2 : Test methods for adhesives

The composition of the Committee responsible for formulation of the standard is given in Annex H.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value observed or calculated expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ADHESIVES FOR USE WITH CERAMIC, MOSAIC AND STONE TILES — SPECIFICATION

(First Revision)

1 SCOPE

This standard prescribes the requirements for adhesives used for fixing tiles of different porosity and classifies the tile adhesive into different types suitable for their proposed application.

This standard covers adhesives for installation of ceramic (vitrified and non-vitrified), porcelain, clay, glass, glass mosaic, metal, natural stone and engineered stone tiles.

NOTE — All interior and exterior wall installations of stone tiles above 3 m height shall be clamped for safety, where the background is not robust enough to support the load of stone tile installation.

2 REFERENCE

The standard listed below contains provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below:

IS No.	*Title*
10890 : 1984	Specification for planetary mixer used in tests of cement and pozzolana

3 DEFINITIONS

For the purpose of this standard, the following definitions shall apply.

3.1 Fine Thin Bed Fixing — A process of tile fixing into a bed of an adhesive average of 2 mm in final bed thickness.

3.2 Thin Bed Fixing — A process of tile fixing into a bed of an adhesive average of 6 mm in final bed thickness.

3.3 Medium Thick Bed Fixing — A process of tile fixing into a bed of an adhesive not less than average 6 mm and not exceeding average 12 mm in final bed thickness.

NOTE — If level variation on floor or wall is more than an average 12 mm in 3 m length (excluding intentional slope for floors, provided for flow of liquids to drain points), surface preparation as required to bring the surface true to plumb level shall be taken up with appropriate materials.

3.4 Open Time — Maximum time interval after application at which tiles can be embedded in the applied adhesive.

3.5 Adjustment Time — Maximum time interval after which tiles positioned in the adhesive layer can be adjusted without significant loss of adhesion.

3.6 Shelf Life — Time storage under stated conditions during which an adhesive is expected to maintain its working properties.

3.7 Slip — Downward movement of a tile embedded in the combed adhesive layer on vertical surface.

3.8 Deformability — Capacity of hardened adhesive to be deformed by stresses between the tile and the fixing surface without damage to the installed surface.

3.9 Transverse Deformation — Deflection recorded at the centre when a beam of hardened adhesive is subjected to three-point loading.

4 CLASSIFICATION

The adhesives shall be classified into 5 types. The recommended application of these types of adhesives are given in **4.1** to **4.5**.

4.1 Type 1 Adhesive

This adhesive is suitable mainly for tiles with apparent porosity greater than 3 percent. It is suitable for most of the clay and ceramic (non-vitrified) tiles of small dimension (size not more than 300 mm x 300 mm) and the majority of cement based backgrounds (substrates) like cement plaster, cement concrete, cement screed, etc, and for interior dry area applications only.

NOTE — Type 1 adhesive generally contains varying small amounts of chemical polymers, hence the name general purpose adhesive is suitable for general, internal, clay or ceramic floor and wall tiling. The vital minor amounts of chemical polymers enable powder adhesives, which are based on bulk cement and filler, to be modified to have appropriate properties.

4.2 Type 2 Adhesive

This adhesive is suitable mainly for tiles with an apparent porosity less than or equal to 3 percent. It is suitable for vitrified/fully vitrified tiles, glass mosaic tiles, all stones, dense and large dimension (More than 300 mm × 300 mm size) tiles and stones (slabs), and where background and location is more demanding like wet areas, submerged areas, etc. This type of adhesive is recommended for both interior floor and wall applications, and for exterior floor applications.

4.3 Type 3 Adhesive

This adhesive is suitable mainly for tiles and stone tiles on exterior wall substrates like plaster or concrete. It is suitable for tiles like ceramic, clay tiles, basalt tiles, vitrified, glass mosaic tiles and porcelain tiles and all natural stone tiles.

4.4 Type 4 Adhesive

This adhesive is suitable mainly for tiles and stone tiles which are included in Type 1, Type 2 and Type 3 but intended for installation on dry wall board substrates. It is suitable for all types of tiles and stones except metal tiles or engineered stones to be installed on dry wall board substrates like gypsum boards, plywood, wood, calcium silicate boards, medium density fibre boards, fiber cement boards, cement boards, bison panel, etc.

For all tiles/stones of size more than 600 mm × 600 mm, the adhesive shall also comply with '*S*1' category of transverse deformation. For all tiles/stones of size more than 1 200 mm × 1 200 mm, the adhesive shall also comply with '*S*2' category of transverse deformation.

Similar results to polymer modified adhesive can be achieved by the addition of a liquid admixture to the standard general purpose adhesive which is called as polymer fortified adhesive. This is a more of specialist and technical solution that provides enhanced adhesion and increased flexibility. Thus, by addition of liquid admixture to Type 1 adhesive, its properties can be enhanced to meet the performance criteria of Type 2 or Type 3 or Type 4 adhesive.

NOTE — Type 2, Type 3 and Type 4 adhesives are more technical products, generally referred as polymer modified adhesives, and are required in situations where the background (substrate) or the tile or the surface is particularly challenging.

4.5 Type 5 Adhesive

This adhesive is suitable for all types of tiles including engineered stones (manufactured stones) which are intended for installation on glass or metallic substrates like, grid iron, mild steel, stainless steel, aluminum or copper, etc. It is suitable for metal tiles, glass tiles, engineered stones or for all types of tiles and stones to be installed on different cement based substrates like cement screeds, plaster, concrete, drywall boards like gypsum boards, plywood, wood, metals composite boards, modified backer boards and the metallic substrates.

NOTE — Type 5 adhesive is generally a mixture of synthetic resin, mineral fillers and organic additives in which hardening occurs by chemical reaction. They are available in one or more component forms and in essence, these cover polyurethanes, epoxy adhesives and the like.

5 REQUIREMENTS

5.1 Tensile Adhesion Strength

When tested in accordance with the method given in Annex A, the mean tensile adhesion strength of adhesive shall comply with the requirements given in Table 1.

5.2 Shear Adhesion Strength

When tested in accordance with the method given in Annex B, the mean shear adhesion strength of adhesive shall comply with the requirements given in Table 1.

5.3 Open Time

When tested in accordance with the method given in Annex C, the open time shall not be less than that stated by the manufacturer.

Table 1 Minimum Tensile and Shear Adhesion Strength of Adhesive

(*Clauses* 5.1 *and* 5.2)

Sl No.	Characteristic	Requirement N/mm^2				
		Type 1	Type 2	Type 3	Type 4	Type 5
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Tensile adhesion strength, *Min*:					
	a) Dry condition	0.5	1.0	1.5	1.5	2.0
	b) Wet condition	—	1.0	1.0	1.0	—
ii)	Shear adhesion strength, *Min*:					
	a) Dry condition	1.0	1.25	1.5	1.5	6.0
	b) Heat aging condition	—	1.0	1.0	1.0	3.0
	c) Wet condition	—	1.0	1.0	1.0	—

5.4 Adjustment Time

When tested in accordance with the method given in Annex D, the adjustment time shall not be less than that stated by the manufacturer.

5.5 Slip (Required for Vertical Application Only)

When tested in accordance with the method given in Annex E, the slip shall not be more than 0.5 mm. Slip resistant adhesives shall be designated as '*T*'.

5.6 Deformability (Required for Vertical Application Only)

When tested in accordance with the method given in Annex F, the deformability shall be within the range mentioned below for a particular class as stated by the manufacturer:

Sl No.	*Classification*	*Transverse Deformation*
i)	Deformable adhesive, *S*1	≥ 2.5 mm, < 5.0 mm
ii)	Highly deformable adhesive, *S*2	≥ 5.0 mm

6 CONDITIONING

Unless otherwise stated, all the tests shall be carried out at standard atmospheric conditions of 27 ± 2 °C temperature and 65 ± 5 percent humidity.

7 INSTRUCTIONS

Adhesive supplied in accordance with this standard, when mixed and spread in accordance with the manufacturer's instructions, shall be suitable for tile/stone fixing on those types of background for which they are recommended by the manufacturer. The manufacturer's instruction shall be carefully followed when any pre-mixing of the adhesive is required.

8 PACKING AND MARKING

8.1 Packing

The packing of the adhesive shall comply with the following:

a) Adhesive shall be suitably packed in leak proof and moisture proof bags or containers, and
b) Liquid admixture/liquid components of adhesive shall be bottled in suitable leak proof and moisture proof containers.

8.2 Marking

8.2.1 Each bag or liquid container of adhesive shall be legibly and indelibly marked with the following:

a) Name of the manufacturer and the trade-mark, if any;
b) Batch or lot number;
c) Month and year of manufacturing;
d) Type of adhesive that is Type 1 or Type 2 or Type 3 or Type 4 or Type 5;
e) Special characteristics:
    1) *Deformability* — To be marked with '*S*1' or '*S*2', if and as applicable.
    2) *Slip resistance* — To be marked with '*T*', if applicable.
f) Open time and adjustment time of the adhesive;
g) Storage life and storage condition for the adhesive; and
h) Appropriate mixing instructions.

8.2.2 *BIS Certification Marking*

The product(s) conforming to the requirement of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the products may be marked with the standard mark.

ANNEX A

(*Clause* 5.1)

DETERMINATION OF TENSILE ADHESION STRENGTH

A-1 APPARATUS

A-1.1 Square Notched Trowel — Trowel used shall be with 6 mm × 6 mm square notch trowel with a clear internal gap of 6 mm between adjacent notches.

A-1.2 Weight — Weight shall be of mass 2 kg occupying less than 50 mm × 50 mm cross-sectional area.

A-1.3 Pull Head Plates — These shall be square or circular metallic plates, with dimensions of 50 ± 1 mm edge or diameter and a minimum thickness of 8 mm with a suitable fitting for connection to the test machine.

A-1.4 Universal Testing Machine (UTM) — UTM shall be capable of applying the load to the pull head plate at the rate of 250 ± 50 N/s through a suitable fitting that does not exert any bending force.

A-1.5 Laboratory Oven, controlled at 70 ± 3 °C.

A-1.6 Concrete Test Substrate — Concrete test substrate shall be 40 ± 5 mm thick, having a moisture content of less than 3 percent by mass, and water absorption at the surface after four hours of testing in range of 0.5 cm^3-1.5 cm^3. The cohesive strength shall be at least 1.5 N/mm^2.

NOTES

1 A method for manufacturing a suitable concrete test slab and the procedures for measuring the cohesive strength and surface water absorption is given in Annex G for information only.

2 *Other test substrates* — Other substrates may be used upon agreement, if the substrate is recommended for tile application by the adhesive manufacturer. To demonstrate compatibility with other optional substrates, the adhesive shall be applied to the selected substrate with cohesive strength of greater than 1.0 N/mm^2 or if cohesive failure occurs in the substrate, the requirement is considered satisfied.

A-1.7 Mixer for Mixing the Adhesive — *See* IS 10890 for specification of mixer.

NOTE — Use of mixer is recommended for mixing the adhesive.

A-2 FAILURE PATTERNS

The modes of failure may be a combination of any of that given below, which shall be recorded for each specimen:

a) *Adhesion failure (AF-S or AF-T)* — Failure occurs at the interface between adhesive and substrate (AF-S) (*see* Fig. 1A) or between tile and adhesive (AF-T) (*see* Fig. 1B). The test value equals the adhesive strength. In some cases the failure may occur in the adhesive layer between the tile and the pull head plate (BF) (*see* Fig. 1C). In this case, the adhesive strength is greater than the test value and the test shall be repeated.

b) *Cohesive failure within the adhesive (CF-A)* — Failure occurs within the adhesive layer (*see* Fig. 1D).

c) *Cohesive failure in the substrate or in the tile (CF-S or CF-T)* — The failure occurs within the substrate (CF-S) (*see* Fig. 1E) or within the body of the tile (CF-T) (*see* Fig. 1F). In this case, the strength of the adhesive is greater than the test value.

A-3 TEST SPECIMENS

A-3.1 For tensile adhesion strength test, tile or stone shall be cut to sizes of 50 ± 1 mm × 50 ± 1 mm, with a nominal minimum thickness of 6 mm or more. The tile pieces required for the testing shall be five for each test condition. Hence, a total of ten tile pieces shall be prepared for tensile testing of an adhesive.

A-3.2 For Type 1 adhesive, ceramic tiles with porosity more than 3 percent shall be used for testing. For Type 2, Type 3, Type 4 and Type 5 adhesives, vitrified or porcelain tiles with porosity less than 3 percent shall be used.

A-4 MIXING OF THE ADHESIVE

The amount of water and/or liquid admixture, required for preparing the adhesive, shall be as stated by the manufacturer in proportion by mass (for example, the amount of liquid, in litres and the amount of powder, in kg to be mixed shall be declared). If a range of values are given, the average shall be used.

A minimum quantity of 2 kg of the adhesive shall be prepared in a mixing bowl using mixer as per IS 10890 with mixing instructions as given in the technical data sheet provided by the manufacturer.

Let the adhesive mature in accordance with the adhesive manufacturer's instructions followed by further mixing for 15 s.

A-5 PREPARATION OF SPECIMENS

A-5.1 Take five test piece tiles of size 50 ± 1 mm × 50 ± 1 mm × 6 mm or higher thickness.

A-5.2 Apply a thin layer of the adhesive, mixed as given above, to the concrete slab with a straight edge trowel. Then apply a thicker layer and comb with a square notched trowel. The trowel shall be held at an angle of approximately 45° to the substrate at a right angle to one edge of the slab and drawn across the slab parallel to that edge (in a straight line). Place at least five test tiles 50 mm apart on the adhesive. Load each tile with 2 kg for 30 s.

A-6 CONDITIONING

Condition one set of five specimens for each of the regimes as appropriate:

a) *Dry condition* — After storing for 27 days under standard conditions, bond the pull head plates to the tiles with a suitable high strength adhesive (*Example*, Epoxy). After further 24 h storage under standard conditions, determine the tensile adhesion strength of the adhesive as per the procedure given in **A-7**.

b) *Wet condition* — Condition the specimens under standard conditions for 7 days and thereafter immerse in water at standard temperature. After a total of 20 days, remove the specimens from water, wipe with a cloth, and bond the pull head plates to the tile or stone. After a further 7 h under standard conditions, immerse the specimen in water at standard temperature.

   On the following day (that is after a total of 21 days), remove the specimens from water and immediately determine the tensile adhesion strength of the adhesive as per the procedure given in **A-7**.

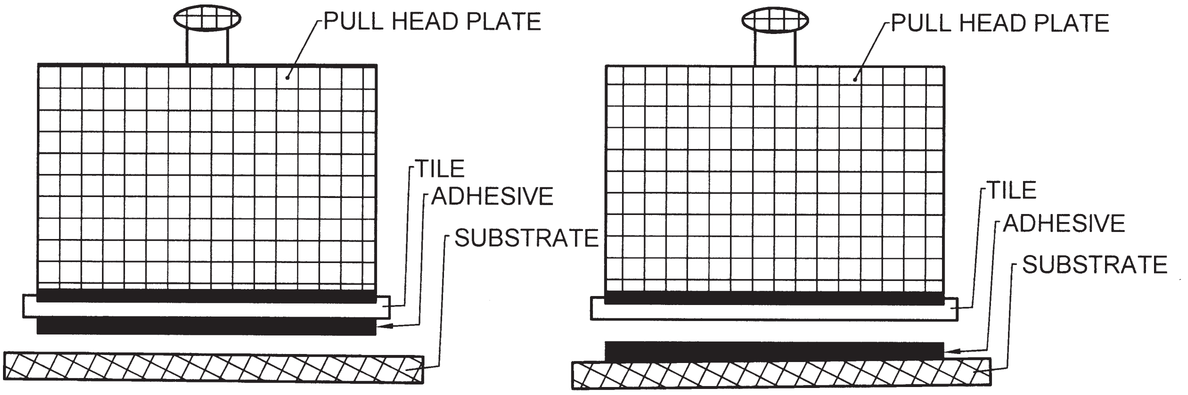
A-7 PROCEDURE

A-7.1 After pull head plates are strong enough, determine the tensile adhesion strength of adhesive by placing the tile on concrete slab to be tested exactly in axial line of pull head, and subject the unit to tensile loading at a rate of 250 ± 50 N/s to the specimen. Note the tensile adhesion strength of the specimen. A suitable arrangement shall be made for clamping the substrate to hold in position while the test is in progress.

A-7.2 Failure of the unit shall be deemed to have occurred when the applied force reaches a maximum value. Then test each of the other specimens similarly. If one or both of the test tiles are broken in the test, record the value at which the breakage occurs, and include it in the mean tensile adhesion strength calculation if, the value is within 15 percent of the mean value. Discard any individual result in which the breaking force differs by more than 15 percent from the mean value. If 3 or more out of the 5 units fail at forces outside these limits, repeat the whole test.

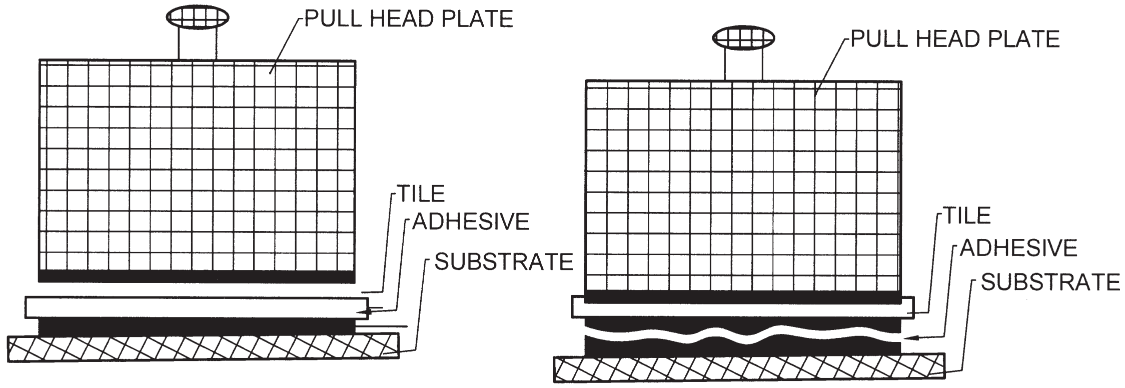
A-8 EXPRESSION OF RESULTS

Calculate for each conditioning sequence the tensile adhesion strength (N/mm^2) as the mean tensile adhesion breakage of at least three specimens. The bond area for calculating the adhesive tensile strength may be taken as 85 percent for normal conditions and 95 percent for high demanding conditions.



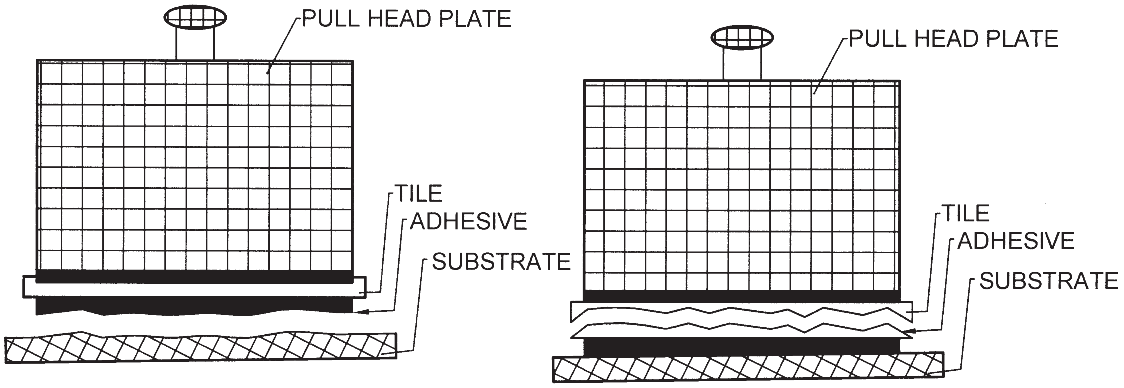
1A ADHESIVE FAILURE BETWEEN ADHESIVE AND SUBSTRATE

1B ADHESIVE FAILURE BETWEEN TILE AND ADHESIVE



1C ADHESIVE FAILURE BETWEEN TILE AND PULL HEAD PLATE

1D COHESIVE FAILURE WITHIN THE ADHESIVE



1E COHESIVE FAILURE WITHIN THE SUBSTRATE

1F COHESIVE FAILURE WITHIN THE TILE

FIG.1 FAILURE PATTERNS

ANNEX B

(*Clause* 5.2)

DETERMINATION OF SHEAR ADHESION STRENGTH

B-1 APPARATUS

B-1.1 Square Notched Trowel — *See* **A-1.1**.

B-1.2 Support for Shear Specimen — Test Unit Holder — Support for shear bond specimens shall be as given in the shear bond test jig (*see* Fig. 2) to place the tile such that edges are loaded against the non-movable support.

B-1.3 T- Spacer Bar, made of brass or steel and shall be as given in Fig. 3.

B-1.4 Universal Testing Machine (UTM) — UTM shall be capable of applying the compression load with displacement at the rate of 5 ± 0.5 mm/min.

B-1.5 Laboratory Oven, controlled at 70 ± 3 °C.

B-2 TEST SPECIMENS

B-2.1 For Type 1 adhesive, ceramic tiles with porosity more than 3 percent shall be cut to size of 100 ± 1 mm × 100 ± 1 mm, with a nominal minimum thickness of 6 mm or more. Two test pieces are required for each specimen (test unit). Five such cut tiles are required for Type 1 adhesive for each condition.

B-2.2 For Type 2 to Type 5 adhesives, vitrified or porcelain tiles with porosity less than 3 percent shall be cut to size of 100 ± 1 mm × 100 ± 1 mm, with a nominal minimum thickness of 6 mm or more. Two test pieces are required for each specimen (test unit). Five such cut tiles are required for each of the Type 2 to Type 5 adhesive for each condition.

B-3 PREPARATION OF SPECIMENS

Prepare mortar as specified in **A-4**. Assemble 5 shear specimens of 100 ± 1 mm × 100 ± 1 mm tile for each condition, with a minimum of 3 mm mortar layer by bonding the two pieces of tile together for each specimen. The 3 mm mortar bonding layer shall be established by placing 3.2 mm thick T- spacer bar on the smallest tile edge; be sure to rub all of the mortar off the underside of the spacers by sliding them back and forth along the edge. The top tile shall be placed with the cut edge opposite to that of the bottom tile's cut edge and squeezed until a 3 mm thickness of mortar is obtained. The specimen shall be constructed so that the cut edge will be loaded. The tile shall then be slid back and forth along the stainless steel spacers to ensure proper thickness of the mortar. The tile shall then be slid to ensure a 6-8 mm offset. Care shall be taken in removing the stainless steel spacer so as not to cant or slide the tiles in relation to each other or to alter the offset distance. Specimens shall not be individually handled for 24 h and shall be treated with care until broken.

B-4 CONDITIONING

Condition one set of five specimens for each-of the regimes as appropriate:

a) *Dry condition* — 28 days under normal laboratory conditions.

b) *Heat ageing condition* — 14 days under normal laboratory conditions followed by 14 days at 70 ± 3 °C.

c) *Wet condition* — 7 days under normal laboratory conditions followed by 21 days in water at laboratory temperature.

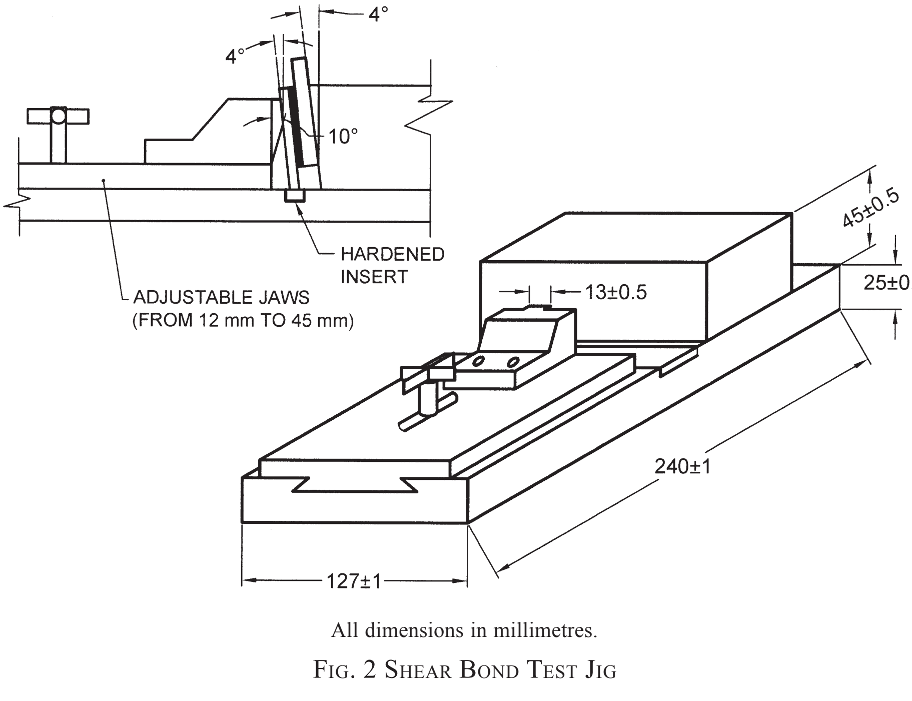
B-5 PROCEDURE

B-5.1 On completion of conditioning, remove the specimen from the conditioning environment. Remove five specimens assembled as directed above. Insert it into the test unit holder mounted in the UTM machine and individually test with compression loading with displacement at a rate of 5 ± 0.5 mm/min, so that the mortar is stressed to failure. Record these values.

B-5.2 Each specimen shall be tested and the failure load shall be recorded. If one or both of the test tiles are broken in the test, record the value at which the breakage occurs, and include it in the mean shear adhesion strength calculation if, the value is within 15 percent of the mean value. Discard any individual result in which the breaking force differs by more than 15 percent from the mean value. If more than three out of the five units fail at forces outside these limits, repeat the whole test.

B-6 EXPRESSION OF RESULTS

Calculate for each conditioning sequence, the shear adhesion strength (N/mm^2) as the mean shear adhesion breakage of at least three specimens.



All dimensions in millimetres.

FIG. 2 SHEAR BOND TEST JIG

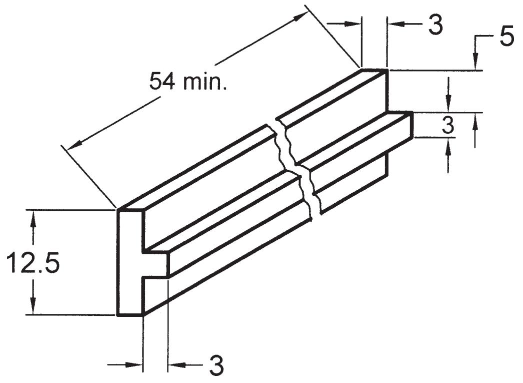


FIG. 3 SPACER BAR

ANNEX C

(*Clause* 5.3)

DETERMINATION OF OPEN TIME

C-1 APPARATUS

C-1.1 Square Notched Trowel — Trowel used shall be with 6 mm x 6 mm square notch trowel with a clear internal gap of 6 mm between adjacent notches.

C-2 TEST SPECIMENS

C-2.1 For open time test, tile shall be cut to size of 50 ± 1 mm x 50 ± 1 mm, with a nominal minimum thickness of 6 mm or more. Ten such tiles have to be prepared for the test.

C-2.2 Ceramic tiles with absorption more than 3 percent shall be used for Type 1 adhesive and vitrified or porcelain tiles with less than 3 percent absorption shall be used for Type 2 or Type 3 or Type 4 or Type 5 adhesives.

C-3 PROCEDURE

C-3.1 The adhesive shall be applied onto a gypsum board using trowel. Tile pieces of size 50 ± 1 mm × 50 ± 1 mm shall be fixed to the adhesive with a 2 kg of mass placed on the tiles for 30 s to improve the contact.

C-3.2 At definite intervals of time, say 5 min, 10 min, 15 min, etc, each designated tile, each time be flipped to see the area of contact of adhesive behind the tile.

C-4 RESULT

The open time is defined as the last measurement of time in minutes before the adhesive fails to wet minimum of 50 percent of tile area.

ANNEX D

(*Clause* 5.4)

DETERMINATION OF ADJUSTMENT TIME

D-1 APPARATUS

D-1.1 Square Notched Trowel — Trowel used shall be with 6 mm × 6 mm square notch trowel with a clear internal gap of 6 mm between adjacent notches.

D-2 TEST SPECIMENS

D-2.1 For adjustment time test, tile shall be cut to size of 50 ± 1 mm × 50 ± 1 mm, with a nominal minimum thickness of 6 mm or more. Ten such tiles have to be prepared for the test.

D-2.2 Ceramic tiles with absorption more than 3 percent shall be used for Type 1 adhesive and vitrified or porcelain tiles with less than 3 percent absorption shall be used for Type 2 or Type 3 or Type 4 or Type 5 adhesives.

D-3 PROCEDURE

D-3.1 The adhesive shall be applied onto a gypsum board using trowel. Tile pieces of size 50 ± 1 mm × 50 ± 1 mm shall be fixed to the adhesive keeping a minimum gap of 35 mm between adjacent tiles, with a 2 kg of mass placed on the tiles for 30 s to improve the contact.

D-3.2 At definite intervals of time, say 5 min, 10 min, 15 min, etc, each designated tile, each time be rotated through 90° and then turned back to its original position.

D-4 RESULT

The adjustment time is defined as the last measurement (time in minutes) before the tile fails to rotate.

ANNEX E

(*Clause* 5.5)

DETERMINATION OF SLIP

E-1 APPARATUS (*see* Fig. 4)

E-1.1 Steel straight edge.

E-1.2 Clamps, to hold the straight edge in place.

E-1.3 Masking Tape, approximately 25 mm wide shall be used.

E-1.4 Two pieces of 25 ± 0.5 mm × 25 ± 0.5 mm × 10 ± 0.5 mm spacers made from stainless steel shall be used.

E-1.5 A weight of mass 5 kg with a cross-sectional area less than 100 mm × 100 mm shall be used.

E-1.6 Vernier Caliper, accurate to 0.01 mm shall be used.

E-1.7 Concrete test substrate as specified in **A-1.6** shall be used.

E-1.8 Square Notched Trowel — Trowel used shall be with 6 mm × 6 mm square notch trowel with a clear internal gap of 6 mm between adjacent notches.

E-2 TEST SPECIMENS

E-2.1 For slip test, tile shall be cut to sizes of 100 ± 1 mm × 100 ± 1 mm, with a nominal minimum thickness of 6 mm or more. Three such tiles have to be prepared for the test.

E-2.2 For Type 1 adhesive, ceramic tiles with porosity more than 3 percent must be used for testing. For Type 2, Type 3, Type 4 and Type 5 adhesives, vitrified or porcelain tiles with porosity less than 3 percent should be used.

E-3 PROCEDURE

Prepare mortar as specified in **A-4**. Secure the steel straight edge at the top of the concrete substrate so that its bottom edge is horizontal when the slab is raised to its vertical position. Position 25 mm wide masking tape immediately below the steel straight edge, and apply a thin layer of the adhesive to the concrete slab with the straight edge of trowel.

Then apply a thicker layer of adhesive to the surface of the concrete substrate so that it just overlaps the bottom edge of the masking tape. Comb the adhesive at right angles to the straight edge with trowel, holding at 45° to the base of concrete substrate.

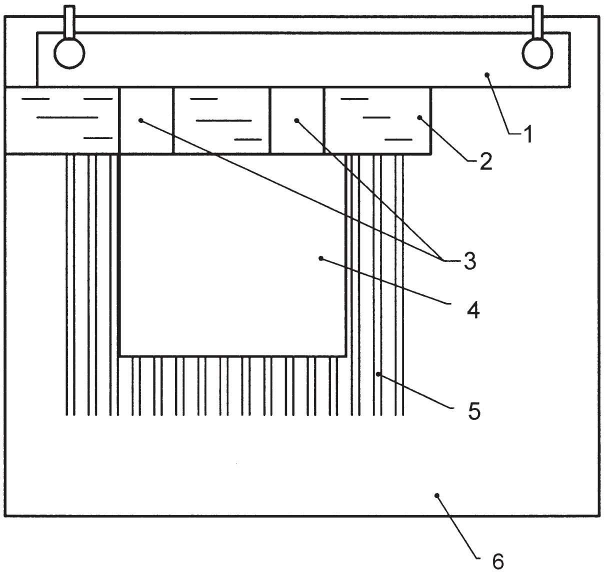
Immediately remove the masking tape, position 25 mm spacers as shown against the straight edge; and after 2 min, place the 100 ± 1 mm × 100 ± 1 mm cut tile specimen against the spacers as shown in Fig. 4 and load it with a weight of mass 5 kg for 30 ± 5 s.

Remove the spacers, and measure the gap between the straight edge and the tile with the vernier caliper to within 0.1 mm accuracy. Then lift the concrete substrate slab carefully into a vertical position. After 20 ± 2 min, re-measure the gap, as before, at its maximum point. The maximum slip of the tile under its own weight is the difference between the two readings.

Carry out the test for three tile specimens and report each individual result and the mean value in mm.

E-4 TEST RESULTS

Slip in millimetres shall be reported for individual and average value. Tile must not sag more than 0.5 mm from its original position.



1. STEEL STRAIGHT EDGE
2. MASKING TAPE 25 mm WIDE
3. (25 x 25 x100) mm THICK SPACER OF SPACING BARS
4. TILE (100 x 100) mm
5. ADHESIVE
6. CONCRETE SLAB

FIG. 4 SLIP APPARATUS

ANNEX F

(*Clause* 5.6)

DETERMINATION OF DEFORMABILITY

F-1 APPARATUS

F-1.1 Substrate — Polyethylene film with minimum thickness of 0.15 mm.

F-1.2 Plastic Container — A plastic container that is capable of being sealed to make it air tight, with an internal volume of 26 ± 5 litre (say, a container with dimensions 600 ± 20 mm × 400 ± 10 mm × 110 ± 10 mm).

F-1.3 Support — Rigid, smooth and flat support for the polyethylene film.

F-1.4 Anvil — A metallic construction with dimensions as shown in Fig. 5.

F-1.5 Test Jig — Two metallic cylindrical supports of diameter 10 ± 0.1 mm, spaced 200 ± 1 mm centre to centre, of length 60 mm minimum (*see* Fig. 6).

F-1.6 Template A — A smooth, rigid, non-absorbent rectangular frame of internal dimensions 280 ± 1 mm × 45 ± 1 mm × 5 ± 0.1 mm [For example, made from polytetrafluoroethylene (PTFE) or metal] (*see* Fig. 7).

NOTE — A round hole of 2 mm diameter drilled at each internal corner is recommended to ease production of the test piece.

F-1.7 Template B — A smooth, rigid, non-absorbent mould or similar device capable of producing a test specimen of dimensions 300 ± 1 mm × 45 ± 1 mm × 3 ± 0.05 mm (*see* Fig. 8).

F-1.8 Test Machine — The test machine shall be a press, capable of applying the anvil to the test piece at a rate of 2 mm/min.

F-1.9 Flow Table — The flow table used for the compaction of the 280 mm × 45 mm × 5 mm specimen (*see* Fig. 9).

F-2 TEST SPECIMENS

F-2.1 Preparation of Substrate

Fix the polyethylene film firmly to the rigid support, ensuring the surface to which the adhesive is to be applied is not distorted (that is, without pleats or wrinkles).

F-2.2 Preparation of Test Units

Hold the Template A firmly onto the polyethylene film. Trowel sufficient adhesive across the template and then screed clean so as to neatly and completely fill the hole in the template. Clamp the mould firmly to the flow table and compact the sample using 70 jolts. Lift the mould gently from the flow table and carefully remove the template vertically. Apply a layer of release agent to the Template B and position it centrally over the specimen. Load the template with a weight capable of exerting a force of 100 ± 0.1 N and an approximate cross-sectional area of 290 × 45 mm. The applied pressure ensures that the material fully fills the recess of the template to the required thickness. Remove any excess material from the sides of the template and 1h later, remove the weight. After 48 h, remove the template. Prepare five samples for each test

F-3 PROCEDURE

F-3.1 Conditioning

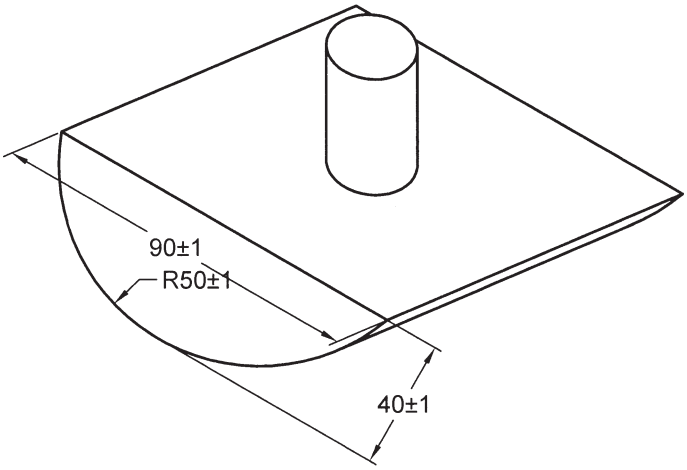
Immediately after the removal of Template B place five specimens, on the support, horizontally into the plastic container and seal it to make it air tight. Condition the test units at 27 ± 2 °C. After 12 days remove them from the plastic container and condition them for 14 days in air in standard conditions.

F-3.2 Transverse Deformation

After conditioning has been completed, remove the specimens from the polyethylene film and measure their thickness, using a caliper with 0.01 mm precision, at three positions, that is, in the middle and 50 ± 1 mm from each end. If the three values fall within the required tolerance of 3.0 ± 0.1 mm, calculate the average value; discard any specimen which falls outside the required permissible thickness. Place the test sample on the test jig. The starting point is defined when the anvil touches the sample. Deform the sample, from the starting point, with a transverse load applied by the anvil at a rate of 2 mm/min until failure. Record the deformation from the starting point, in mm. Repeat the test on the other test pieces. Discard any individual result in which the deformation differs by more than 15 percent from the mean value. If more than three out of the five units result deformation values outside these limits, repeat the whole test.

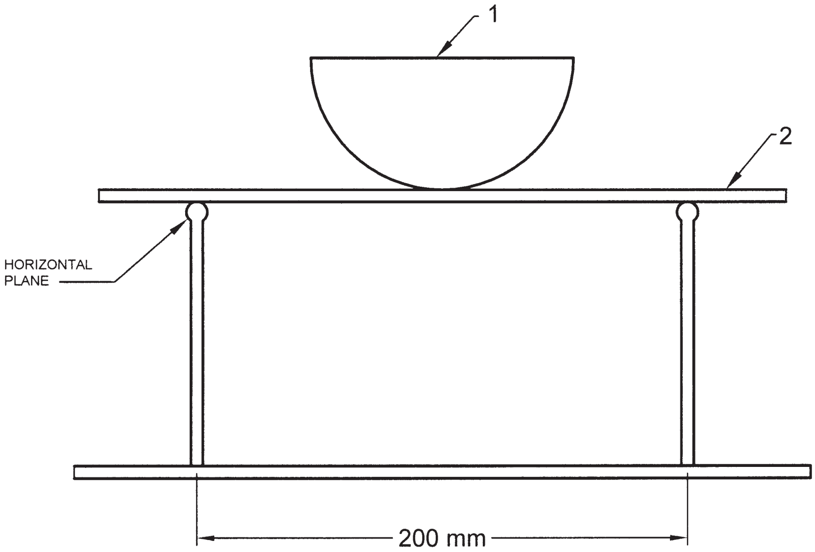
F-4 TEST RESULTS

The transverse deformation is determined to 0.1 mm, by calculating the average value of the deformations obtained in the test. Deformation value in millimetre shall be reported for individual and mean values for deformability of adhesive (mm). The adhesive deformability is classified as '*S1*' or '*S2*' Class based on the result obtained from this test.



All dimensions in millimetres.

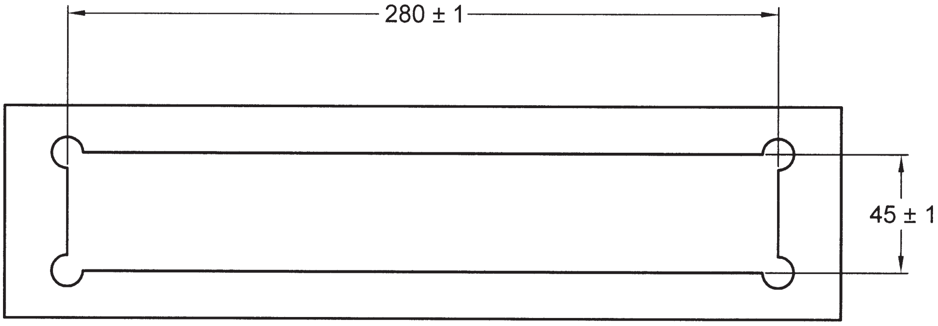
Fig. 5 Anvil



1. Cylinderical support diameter (10 ± 0.1 mm). Length 60 mm minimum

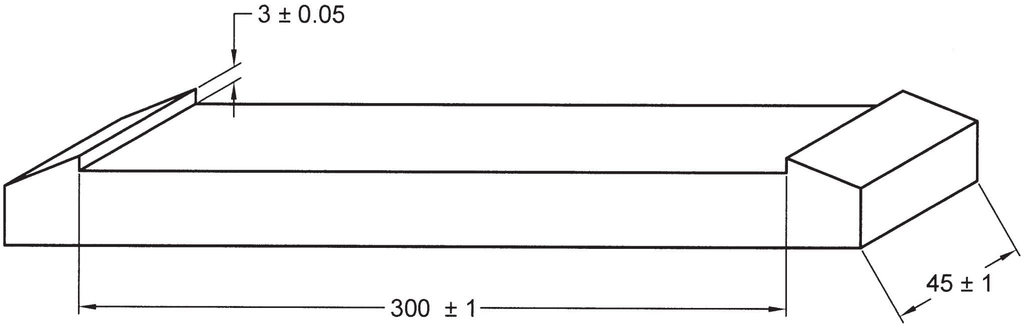
2. ADHESIVe (3 ± 0.1 mm) THICK

Fig. 6 Test Jig



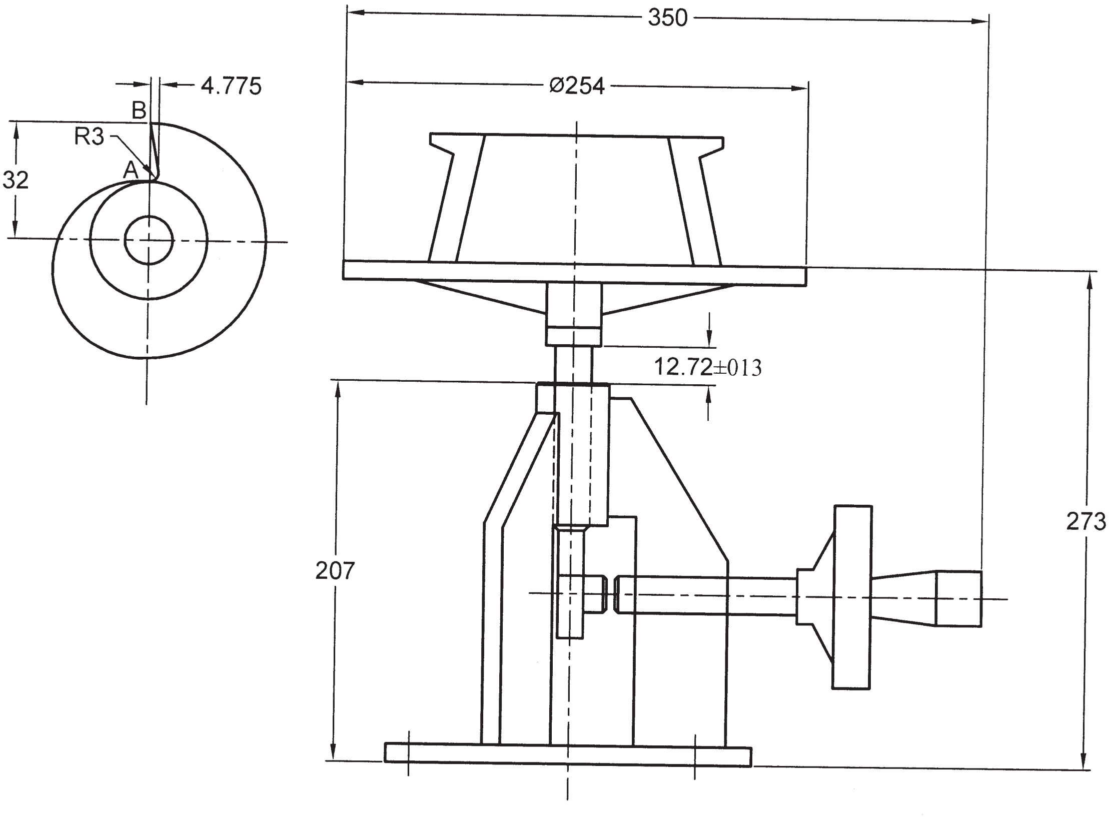
All dimensions in millimetres.

Fig. 7 Template A



All dimensions in millimetres.

FIG. 8 TEMPLATE B



All dimensions in millimetres.

FIG. 9 FLOW TABLE

ANNEX G

(*Clause* A-1.6)

CONCRETE TEST SLAB

G-1 GENERAL INFORMATION

A concrete test slab suitable for the adhesive tests described in this standard may be manufactured and tested using these described procedures.

G-2 TEST CONDITIONS

Test conditions given in **5** shall apply.

G-3 APPARATUS

G-3.1 Pull Head Plates — As given in **A-1.3**.

G-3.2 Universal Testing Machine (UTM) — As given in **A-1.4**.

G-3.3 Carsten-Rohrchen Flask, or other suitable apparatus for measuring the water absorption at the surface of the concrete slab (*see* Fig. 10).

G-4 CONCRETE TEST SLAB

G-4.1 Manufacture of the Concrete Slab

The specification (listed in **A-1.6**) may be achieved by using the following procedure to manufacture the concrete slab:

a) Binder : Portland cement.

b) Aggregate : Gravel sand, of up to 8 mm particle size, continuous grading curve between A and B (*see* Fig. 11).

c) Mix ratio of binder and aggregate : 1:5 in proportion by mass.

d) Ultrafines content per m^3 of concrete : 500 kg/m^3 prepared concrete shall contain concrete ultrafines in order to be properly workable and have a closed structure: the ultrafines content consists of cement and aggregate particle size up to 0.125 mm.

e) Water-cement ratio : 0.5

f) Manufacture : Vertically or horizontally in moulds, avoid the use of any mould release agent.

g) Compaction : 90 s on a vibrating table at 50 Hz.

h) Conditioning : The slabs shall be stored for 24 h under standard conditions followed by 6 days water immersion at 20 ± 2°C.

Before use or before being tested for water absorption and surface cohesive strength, the concrete slabs shall be stored separately, in vertical position, in a dry and ventilated environment, for at least 3 months and conditioned for at least 24 h under standard test conditions.

The test surface shall have a finish similar to that obtained by using a wooden float and shall be clean and dust-free at the time of the test.

G-4.2 Measurement of Surface Water Absorption

Water absorption at the surface of the concrete slab shall be determined by the following method:

a) Bond a measuring tube graduated in ml (Carsten Rohrchen flask) to the concrete slab by means of a suitable sealant.

b) After the sealant has cured, fill the measuring tube with water, to the upper level.

c) Record the drop in water level during the 4 h duration of the test. The total drop in water level at the end of 4 h gives the surface water absorption.

d) Perform at least three tests on a reference concrete slab from each batch and calculate the average surface absorption.

G-4.3 Measurement of Surface Cohesive Strength

The tensile strength between the pull head plate and concrete surface shall be at least 1.5 N/mm^2. The strength shall be determined by bonding at least five pull-head plates directly to the slab, for example, with an epoxide resin, and determining the tensile adhesion strength by applying a force which increases at a constant rate of 250 ± 50 N/s.

G-4.4 Measurement of Moisture Content

The specimen of size 100 mm × 100 mm shall be weighed, W_1 shall be weighed to nearest 1 g. The specimen, then, shall be dried out at 105 ± 5°C in a thermostatically controlled oven until constant mass is obtained within a duration of 4 h. Immediately after remvoing from the drying oven, the specimen shall be weighed (if necessary by cooling to room temperature in a suitable desiccator), and weighed, *W* obtained. The moisture content, in percent of the dry block, shall be determined as follows, correct to one decimal place:

$$= (W_1/W - 1) \times 100$$

G-4.5 Data Recorded

The following items shall be recorded:

a) Description of the concrete slab and reference to the batch;

b) Handling and storage of concrete slabs before testing;

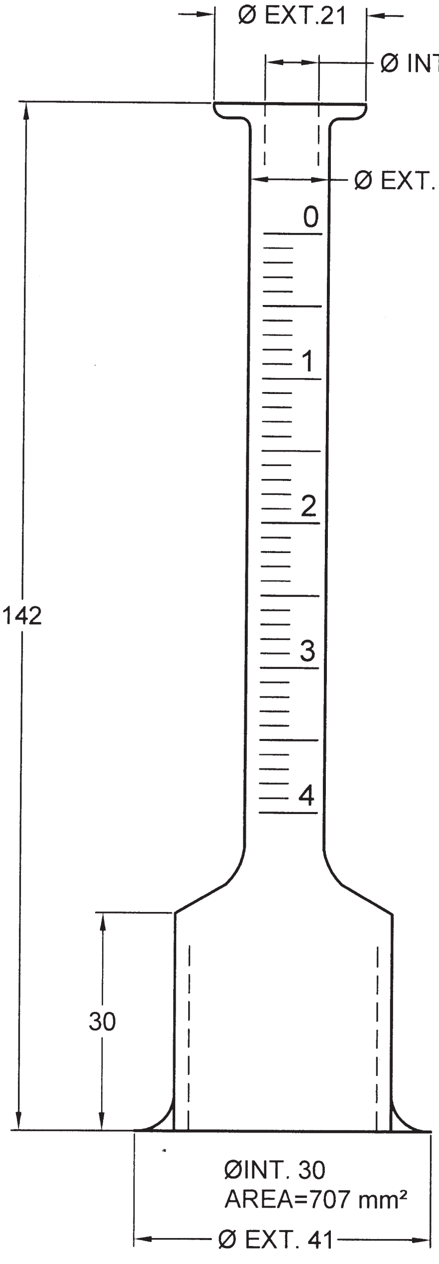
c) Water absorption of concrete slab, representative of the batch;

d) Moisture content of the concrete slabs, representative of the batch;

e) Tensile adhesion strength of concrete slab, representative of the batch;

f) Any other factor that might have influenced the result; and

g) Date of test.



All dimensions in millimetres.

Fig. 10 Apparatus for Evaluating Water Absorption (Carsten — Rohrchen Flask)

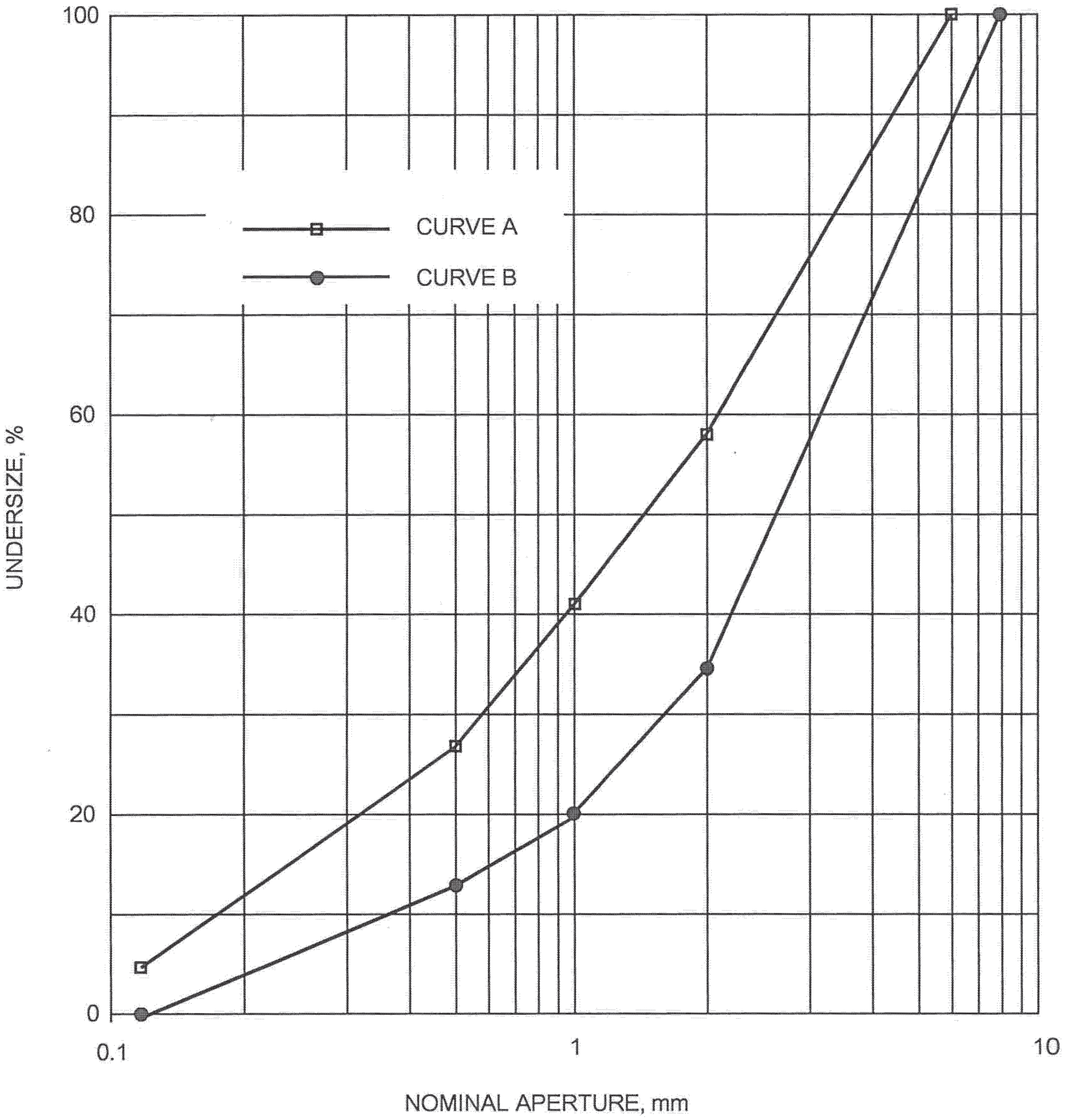


FIG. 11 GRADING CURVES FOR 8 mm MAXIMUM PARTICLE SIZE

ANNEX H

(*Foreword*)

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